Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 79 (2015) 175 – 182

Energy Procedia

2015 International Conference on Alternative Energy in Developing Countries and Emerging Economies

Energy Transitions for the Rural Community in Kenya's Central Highlands: Small Scale Solar Powered Systems

Harrison Ngetha[a,b*], Minoru Sasaki[a], Meisam Taheri[a], Stephen Mathenge[b]

[a]*Department of Mechanical Engineering, Faculty of Engineering, Gifu University, 1-1 Yanagido, Gifu, 501-1193 Japan*
[b]*Department of Electrical & Electronic Engineering, School of Engineering, Dedan Kimathi University of Technology, P.O. Box 657-10100 Nyeri, Kenya*

Abstract

This paper explores Kenya's central highlands rural community's sources of energy choices' in the last three decades. The paper tracks the changes in sources of energy (firewood, charcoal, kerosene, car battery and dry cells) up to the option of using the solar homes systems. In Kenya, the demand for clean energy for both industrial and domestic activities is on the rise. Currently, the energy for the industries and urban areas is derived largely from petroleum and hydroelectric power. On the other hand, for the low-income earning rural community in the Kenya's central highlands, firewood is however the major source of energy for most domestic activities. Considering that arid and semi-arid regions constitute over 80% of the country, the demand for firewood for instance impacts the natural ecosystems and disrupts the natural nutrient cycling.

Peer-review under responsibility of the Organizing Committee of 2015 AEDCEE

Keywords: Kenya's Central highlands, solar energy, wind power, sources of energy, households

1. Introduction

The central highlands in Kenya, which straddles the equator, exhibits one of the best climates in the country of Kenya, see Fig 1. The area receives direct sunlight for the better part of the year. The

* Corresponding Author. Tel.: +81 58 293 2541; fax: +81 58 293 2541.
E-mail address: thuku@ymail.com (Harrison Ngetha).

Peer-review under responsibility of the Organizing Committee of 2015 AEDCEE
doi:10.1016/j.egypro.2015.11.458

temperatures vary according to time of the year and day, see Fig 2. The warmest to highest temperatures occurs between 9am and noon. The temperatures are moderate, though fluctuating between highs of 29°C in January and lows of 7°C in July, giving a taste of extremes at both ends, see Fig 3. The area has a tropical like climate and has two wet seasons and two dry ones [1]. The major town is Nyeri town which is the Nyeri County headquarters.

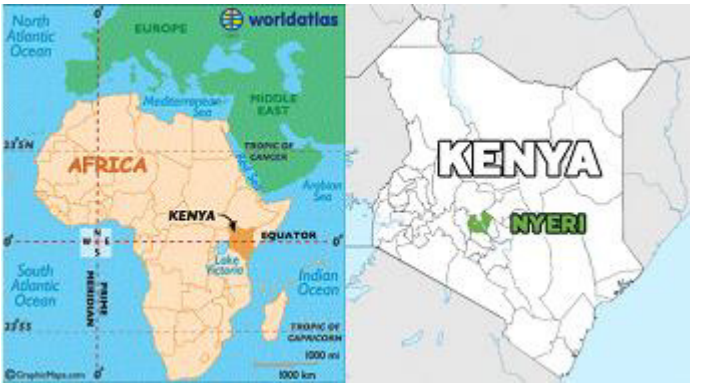

Fig. 1. (a) Geographical maps of Kenya; (b) the Central highlands (courtesy of world atlas)

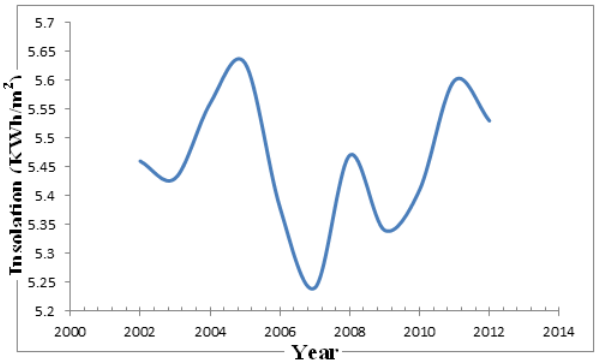

Fig. 2. Average annual insolation of the Kenya's central highlands

Fig. 3. Central Kenya highlands during months of; (a) March; (b) July

A typical rural household in the Kenya's central highland consists of several housing units; the main house, a detached kitchen, usually closer to the main house, the boy's sleeping rooms at a distance from the main house and the domestic animal's shed much closer to the kitchen. In the rural countryside, the educational institutions have large tracks of land and the buildings are usually spread out. This kind of land use and building pattern usually possess lots of inefficiencies especially when it comes to lighting. In both cases the pit latrines are a distance away from the main buildings.

From mid-1970 to the recent times, the access to the national grid supply of electricity, by the Kenya's population, stands at around 44% from 23% in the early 1970's. Despite this achievement, reliable electricity is an oxymoron. Blackouts have been a norm especially in the Kenya's central highlands due to inconsistent supply electricity and high demands. Due to this, solar power systems have been implemented, though in small scale basis, in areas where many rural communities may never get access to the national grid. This is because of the high costs involved, which necessitates significant amount of government subsidies [2]. The decline of coffee and tea prices in the world market has really affected the buying capacity of the small scale farmers in the central highlands. Thus, in the Central Kenya highlands, only fewer than 3% of the rural households are linked to the national grid.

2. Energy Transitions

2.1. Firewood & Kerosene

Traditionally, the main sources of energy, for the rural household in Kenya's central highlands are firewood (cooking and heating) and kerosene (lighting). Depending on the economic status of the household, there exists three different types of kerosene lighting devices; the traditional tin lamp (produced by local artisans), industrially produced wick lanterns and the kerosene pressure lamps, see Fig 3.

Fig. 4. (a) Tin-wick lamp; (b) Glass lamp; (c) Lantern kerosene lamp

Only a few households (teachers and civil servants) could afford the kerosene pressure lamps. The better endowed households used charcoal for cooking in addition to firewood. From as early as 1920's, the *Shamba* system was introduced in Central Kenya highlands, Kenya back then, referred to as the

British East Africa Protectorate. The *Shamba* system allowed farmers to cultivate perennial crops in the Central Kenya highlands forest reserves, for instance, The Hombe area, while at the same time, planting young trees. The area has two major forest reserves under the jurisdiction of the Forest Department and three other forest reserves (*Tumutumu*, *Karima* and *Gatumbiro),* under management of Local Governments. The law required the farmers to evacuate from the forest after three years when the trees were old enough and no longer required their care. Even after independence in 1963, the Shamba system continued up to the late 1990's. This in addition to providing a source of livelihood for the rural community living through cropping, a Firewood Collection system from the forests was also introduced. The Firewood Collection Permit only allowed the collection of one load of firewood per day. The other requirements were that only dry and dead trees would be collected and used only for household consumption and not for commercial purposes. The two systems were however surrounded with controversy and allegations of corruption. Many farmers settled permanently in *Gathirathiru*, *Iruri*, *Hombe* and *Kabaru* areas of Mount Kenya. The original vision of protecting the forest was lost as farmers turned to indiscriminately felling of indigenous trees for charcoal burning kilns, timber and firewood. This led to the degradation of the forest around and within the settlement. Among these areas, Hombe was of great importance. It is the catchment area of rivers Sagana, a major river in Central Kenya highlands, and the river Hombe as well as many other streams. These rivers are the backbone of the agricultural and industrial uses. This threatened the natural ecosystem. As more and more people settled in the forest reserves, there was a lot of pressure on the ecosystem. The degradation of forests through illegal logging which targeted the indigenous trees, because of the quality of charcoal and timber produced, threatened the existence of the rivers. In the early 1990's, the Government of Kenya evicted all the people who had settled in Mt. Kenya forest. The Government embarked on tree planning campaign to reclaim the forest areas which has been dwindling very fast. However the forest is still under threat from illegal loggers. There is always a ready market for charcoal and firewood especially from the local indigenous trees. Most of the businesses as well as the household at the edge of the forest continue to rely on charcoal and firewood as a source of fuel. Most of the households living on the edge of Mt. Kenya do not have sufficient trees on their farms to use as the source of fuel. However, the local governments encourage the planting of fast growing exotic trees which supply constant source of firewood and timber. The major types of trees used are; *Mukima (Grevillea robusta), Muthithida (Cupressus lusitanica)* and *Mubau (Eucalyptus saligna)*.

A survey conducted from 600 households in the *Gathehu*, *Gatei*, *Gitunduti* and *Chehe* sub locations of Mathira Constituency in the Nyeri County, gives an indication of the sources of energy used in cooking, heating and lighting purposes [Table 1]. The use of maize cobs for cooking purposes is only during and after the harvest seasons, see Fig 5a. The task of collecting firewood from the forest reserves usually fell on the rural women. As the supply dwindled, the women had to walk long distances into the forest. On average, to collect one firewood load weighing around 30 kilograms, they had to walk for over 4 hours and covered a distance of not less than 10 kilometres, see Fig 5b.

Fig. 5. (a) Maize cobs hang out to dry, (b) a woman carrying firewood load from the forest

The same practice still takes place nowadays amidst many hazards and dangers. In most cases, especially during evenings, the younger members of the families are tasked with the responsibility of looking for dry twigs in the farm or within the stockpile of the firewood. The older siblings would be required to split firewood for evening meals. The twigs collected by the younger kids would be used to stroke the fire, see Fig 6.

Fig. 6. A lady from Central Kenya highlands enjoying a cup of tea, on a cold morning, with her youngest daughter while keeping warm using an energy saving fire place.

The purchasing power as well as the size of the families, dictated the source of energy and the amount used. In case of firewood, the size of families also meant that more people were available for collecting it.

While the purchasing power meant more use of charcoal to supplement the gas or kerosene uses, see Table 1.

Table 1. Sources of Energy

Energy Source	Uses/Applications	Percentage, %
Firewood, Charcoal, Kerosene	3	74.5
Firewood, Maize-cobs, Kerosene	3	14.9
Charcoal, Gas, Kerosene	3	5.7
Charcoal, Gas	3	4.9

Source of Data: Field Survey 2011/2012

As indicated in the data above, almost all the households had different sources of energy for lighting, heating or cooking. Despite the dwindling forest reserves, firewood accounted for the highest percentage of the source of energy for cooking and heating the houses during the months of July and August, when the temperatures are at the lowest.

In the recent times, illegal logging, charcoal burning and human and livestock settlement has greatly affected the ecosystem of parts of Mt. Kenya forest reserve. This has resulted to water levels on *Sagana*, *Ewaso nyiro* and *Thegu* reducing so much and to an extent, like river *Thegu* drying up especially during the months of January to March. This overall affects the economy of the central Kenya highlands whose main activity is agriculture.

2.2. Dry Cells & Car Battery

During the mid-80's~90's, dry cells were used in powering radios and torches. Ordinarily, new dry cells would be used on the torches for some time before being transferred to the radio. The purchase of the kerosene and the dry cells mostly happened once per month after payday [4]. The television was a luxury item and owning a 'Black & white' TV made one a 'village celebrity'. The color TV was primarily for the local Parish churches, the District and Provincial high schools. The main reason for this is that, only those institutions were connected to national grid system [5]. The rest of the rural folks relied on car batteries to power their TVs. The charging stations at the local shopping centers provided the recharging services, see Fig 7. These charging stations were not operated by trained technical personnel, but by the owners of local retail shops or metal-work workshops. The charging systems were old and mostly locally refurbished. The people tasked with repairing and refurbishing the charging systems were the local 'Jua Kali' artisans. This resulted to a reduced life span of the batteries, due to wrong parameter settings of the charging current and voltages.

Fig. 7. (a) A typical rural shopping centre; (b) A battery charging system

2.3. Solar Home Systems

Despite the levels of sunshine being averagely high for the better part of the year, solar uptake has been slow in the past due to the cost involved in the initial installation. As the years went by and the purchasing power of most of the families improved, a 6 ~ 10W solar panel would be purchased to aid in the charging of the car battery used with the TVs [6]. The wiring would be temporary as this was a step by step process of upgrading the solar home system. After buying the solar panel, it was almost inevitable to upgrade the battery from shallow discharge car battery to deep discharge solar battery. However, this was not done when the need arose, but was done either after the 'Tea Bonus' or the 'Coffee Boom' payouts. The entrant of solar panels as an alternative source of energy coincided with improvement in technology and also the influx of electronics from China which were more affordable to the common 'Mwananchi'.

The initial solar panels that were affordable were physically big and had low power ratings. As the prices dropped, the power rating increased and the physical size reduced, better solar panels became more affordable [7]. At this juncture, a formal and semi-permanent wiring was done. It was semi-permanent because, the power connections between the TV and the radio were mostly used interchangeably. With time this wiring was done in a neater way, though still allowance for expansion or changes was factored in. From the year 2000, DC energy saving bulbs came into the market. Prior to the entrant of energy saving bulbs, the rural folk either used the 20~40W incandescent bulbs or resulted to the locally assembled 2-ft fluorescent lighting system. By around 2008, the low power DC energy saver bulbs came in to the major towns in the Central Kenya Highlands.

At the same time local institutions and small scale electrical companies started fabricating the 12Vdc to 240Vac inverter systems. This was much more suited to the operating environments of most of the households. And by 2010, most of the system had been upgraded to about 70~100W solar panels systems, a charger controller, an inverter and 75~150Ah deep discharge battery system, see Fig 8.

Fig. 8. Typical Solar Home System (a) Panels; (b) Charger controller and Inverter; (c) Batteries

3. Conclusion

A survey conducted by Electrical and Electronic engineering department, Dedan Kimathi University of Technology in 2011/2012 on 600 households in Nyeri County of Central Kenya highlands, indicated that; 93% reported using lights for study and work related activities, 84% on radios and 98% on charging the mobile cellular phones. For the majority (78%), the TV and the lighting in the sitting area were never used at the same time. This implying that, once the TV was switched on, the room lighting was switched off. In most of the households also, the radio and the mobile phone charging were rarely concurrently done. As the purchasing power of the rural community in the Kenya's central highlands improves, more household are investing in Solar Home systems. This coupled with advancement in technology for low power devices, is aiding in conserving the environments as well as improving the lives of the rural folks.

References

[1] Mbuthi, P. N. Hydropower, meteorology and sustainable development in Kenya", *Proceedings of the 4th Kenya Meteorological Society workshop on meteorological research, applications and services*, Mombasa, Kenya, 7th – 11th September 1998.
[2] Stephen Karekezi, John Kimani and Albert Waudo. Annotated Bibliography of Photovoltaics and Solar Water Heaters. Working Paper No. 175, AFREPREN/FWD, Nairobi, 1998
[3] Republic of Kenya, "Scaling up renewable energy program", *investment plan for Kenya;* 2011.
[4] Ministry of Energy Kenya, National Energy Policy, Kenya Gazette, 2012: 55
[5] Theuri D. Solar and Wind Energy Resource Assessment, Kenya Country Report, SWERA Project 2008
[6] Kamfor, Ltd. (2002). Study on Kenya's energy demand, supply and policy strategy for households, small-scale industries and service establishments. Report for Ministry of Energy, Nairobi, Kenya
[7] Hankins, M. Introduction to and limitations of Solar Photovoltaic Power and Choosing Financing Mechanisms for Developing PV markets: Experiences from Several African Countries. Solar Photovoltaics in Africa: Experiences with Financing and Delivery Models, UNDP 2004. 8 – 41